AD-A259 746

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

(2)

3. REPORT TYPE AND DATES COVERED: FINAL 10 Oct 90 TO 30 Sep 92

4. TITLE AND SUBTITLE

INDIVIDUAL DIFFERENCES IN MEMORY DECAY AND RETENTION

5. FUNDING NUMBERS

AFOSR-91-0014
61102F
2313
A7

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10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

93-01478

13. ABSTRACT (Maximum 200 words)

For nearly forty years the generally held belief has been that there were no individual differences in forgetting which were not the result of differences in original learning. This rather surprising conclusion was based on Underwood's 1954 article in which he looked at the retention of "fast" and "slow" learners. Initially, there were large differences between the retention of fast learners and slow learners. As might be expected, the fast learners recalled what they had learned at a much higher level than did the slow learners. But when underwood then equated for initial learning an interesting thing happened--the large difference in retention previously observed now disappeared. That is, when the probability of calling out an item was equated for fast and slow learners, the differences in retention between the fast and slow learners also disappeared. Several studies over the years confirmed Underwood's basic findings and it did indeed appear to be that there were no individual differences in forgetting or memory--only individual differences in initial learning.

14. SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
(U)	(U)	(U)	(U)

FINAL REPORT

INDIVIDUAL DIFFERENCES IN MEMORY DECAY AND RETENTION

AFOSR GRANT AFOSR-91-0014

TO

ROBERT K. YOUNG

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UNIVERSITY OF TEXAS AT AUSTIN

15 DEC 1992

FINAL REPORT

This paper represents the final report of an AFOSR Grant (AFOSR-91-0014) entitled "Individual differences in Memory Decay and Retention" awarded to Dr. Robert K. Young, Department of Psychology, University of Texas at Austin.

For nearly forty years the generally held belief has been that there were no individual differences in forgetting which were not the result of differences in original learning. This rather surprising conclusion was based on Underwood's 1954 article in which he looked at the retention of "fast" and "slow" learners. Initially, there were large differences between the retention of fast learners and slow learners. As might be expected, the fast learners recalled what they had learned at a much higher level than did the slow learners. But when Underwood then equated for initial learning an interesting thing happened--the large difference in retention previously observed now disappeared. That is, when the probability of calling out an item was equated for fast and slow learners, the differences in retention between the fast and slow learners also disappeared. Several studies over the years confirmed Underwood's basic findings and it did indeed appear to be that there were no individual differences in forgetting or memory--only individual differences in initial learning.

Within recent years, Kyllonen and Tirre (1988) reappraised the issue. These LAMP researchers have suggested that Underwood may have confounded learning with memory decay. Using an alternate method of equating for learning they found that the fast learners retained more than did the slow learners.

Thus the issue remains one which has yet to be resolved. The present experiment attempted to resolve the issue by using one set of forgetting curves to predict forgetting taking place in another, independent, task. The first part of the experiment looked at forgetting in a semantic priming task. The design of the experiment is illustrated in Tables 1 and 2. The schematic diagram of the task is shown in Table 1 and examples of the pairs which were used are presented in Table 2.

Table 1 Schematic of the experimental design

Day 1	Day 1	Day 2	Day 57
400 pairs	160 pairs	160 pairs	160 pairs
A,B,C,D,D	A,E	B,F	C,G

(Note: Each letter refers to a different set of 80 pairs of words)

It can be seen from Table 1 that on Day 1 400 pairs of words were first presented to some 300 subjects. From Tables 1 and 2 it can be seen that each letter represents 80 pairs of words of which 40 were similar in meaning and 40 dissimilar. As can be seen from Table 2 half of these pairs were similar in meaning e.g. MOIST-DAMP while half were dissimilar in meaning e.g. TABLE-MUSTARD. The task of the subject was to indicate, by pressing one of two keys as rapidly as possible, whether the pair was similar in meaning. Correct responding was emphasized but reaction time was the response measure employed. In Table 1 it can be seen that D is represented twice. In this case these were pairs which were presented with only about 10 pairs between the first presentation of these pairs and the second presentation of the same pair. In contrast the A pairs had a considerably greater lag. These pairs were presented a second time only after the first 400 pairs were presented. Thus these pairs averaged about a 30-minute lag. The subjects returned the next day to the testing room and were given 160 pairs of which half were repeated from the previous day. Finally, the subjects returned after 8 weeks and again they were given 160 pairs of which half were repeated.

Table 2 Pairs illustrating the design of the experiment

Day 1 400 pairs	Day 1 160 pairs	Day 2 160 pairs	Day 57 160 pairs
A Moist-Damp Table-Mustard	Moist-Damp Table-Mustard		
B Perfect-Faultless Tree-Cowboy		Perfect-Faultless Tree-Cowboy	
C Noonday-Midday Lamp-Pencil			Noonday-Midday Lamp-Pencil
D Sudden-Abrupt Western-Rounded			
D Sudden-Abrupt Western-Rounded			
E	Holy-Pious Uphill-Sedate		
F		Open-Unshut Ugly-cargo	
G			Cranky-Grumpy Foster-Service

Some counterbalancing took place and the A pairs for half the subjects were the E pairs for the other half of the subjects. Similar counterbalancing occurred for the B, F and the C, G pairs. During the shorter Day 2 and Day 57 sessions the subjects were also given tests of working memory and of knowledge.

At the present time only very preliminary results have been obtained. It appears that the savings in the short 10-pair lags averaged about 200 milliseconds while the savings for the 57 day lags averaged about 25 milliseconds. (The data were not available to me this past summer when I had some time to do the analyses.) Subsequent analyses will be done during the spring break in the coming semester.

The second part of the experiment measured retention loss of material not learned in the laboratory but learned in a real-life setting. In this part of the experiment, we looked at forgetting of material learned in introductory psychology classes. To increase our sampling space, we conducted half of the experiment in the fall semester 1991 and the second in the spring semester of 1992. Two different introductory psychology classes were used and these were taught by two different instructors. In each class the instructor used a multiple choice format for his tests and so the procedure we followed for one was the same as that followed for the other. Measurement of forgetting was done in the following manner. Approximately 30 days after the subjects took the first hour exam in their introductory psychology class the subjects came into the psychology department and took a second exam similar to the one first taken 30 days earlier. The test consisted of 15 multiple choice questions taken from initial exam given in the course plus 15 items covering the same material but which were new to the subjects. Finally, another 15 items which included material yet to be covered in the course were also incorporated into the test. Thus the subjects were given a test consisting of 45 multiple choice items. The items were taken from the pool of items used by the respective course instructors and did not represent a departure from the items they would normally use in their examinations. The items which covered new material were included as a measure of test "wiseness" while the items which covered the same material as the original items were included as a measure of memory of the original material.

The difference between their original score on the 15 to-be-repeated items and their score on those same 15 items taken 30 days later will be employed to determine the amount of material which was forgotten. This "amount-forgotten" variable will be correlated with predictions of amount forgotten derived from equations based on the forgetting observed in the priming experiment represented in Tables 1

and 2. Similarly, the amount-forgotten variable will be correlated with the working-memory data as well as the scores on the general-knowledge test. If there are individual differences in forgetting then the correlation between the predicted forgetting obtained from the and the forgetting observed in the psychology test, i. e. "amount forgotten" should be higher than either the correlation found between working memory and "amount-forgotten" or the correlation found between knowledge and "amount forgotten".

Future research. There are a number of different directions future research can go. I have outlined one of these directions in a grant request recently submitted to AFOSR. In this request the interest is in investigating individual differences in forgetting which are independent of initial learning in both implicit and explicit memory. Implicit memory (which represents much the same ability as is measured on the game show Wheel of Fortune) and explicit memory (which represents much the same ability as is measured on the game show Jeopardy) have a number of differences or dissociations (Schacter, 1987). One of these dissociations, for example, is that explicit memory is correlated with intelligence while implicit memory is not. Another appears to be that explicit memory appears to show great retroactive inhibition effects while implicit learning appears to be quite resistant to forgetting. The question here is whether there are individual differences in forgetting in either or both of these memory types. To investigate this we need to develop paradigms which initially answer the question: can there be large amounts of material forgotten in implicit memory. If the answer is affirmative then we can look to see if there are differences in either implicit memory or explicit memory or both which are not accounted for by differences in initial learning. Our AFOSR grant which investigated individual differences in forgetting did not specifically allow a determination of whether or not there were individual differences in these two types of memory.

Other research. Ten 386 computers were bought under the AFOSR grant. Needless to say they were in good condition after the memory experiment had been run. As a consequence these machines have been used in subsequent research and will continue to be used in future research. We write the following paragraphs to give a feeling for what research we have done and what we are going to do.

Evaluation of an intelligent tutoring system. A second experiment which is currently being run is an evaluation of an intelligent tutoring system developed by Dr. Val Shute. One of the problems she has as a LAMP research worker is that it is virtually impossible to get subjects (i.e. Air Force recruits) for more than one session. The intelligent

tutoring system she is evaluating requires subjects to return four times after an initial session. (This would allow pre-test, post-test and three learning sessions in between.) Because of the difficulty in getting subjects for multiple sessions, I offered to collaborate with Dr. Shute and conduct the experiment in my laboratory at the University of Texas using the computers bought under the AFOSR grant. The experiment consists of three groups--Computer, Lecture and Control--and about half the subjects for this experiment have been run. The remaining subjects should be completed by the second week of the spring semester. The results of this research will be presented in the Division C Poster Fair at the 1993 AERA annual meeting which will be held in Atlanta in April.

Probability learning. One of the more interesting areas of research in memory which have been begun in recent years--although the history of unconscious memory goes back for generations--has been the experimental differentiation between explicit and implicit memory. One finding, which has been replicated in our laboratory has been that explicit memory is correlated with intelligence while implicit memory is not. This has set off a scramble to classify various memory tasks as to whether or not they are correlated with intelligence.

According to expectations, performance on explicit memory tasks should be correlated with intelligence while performance on implicit memory tasks should not be correlated with intelligence. But just which tasks are implicit tasks and which are explicit tasks? There are tasks for which arriving at the appropriate classification is not easy. One such task is called the probability learning or event matching task. For example, suppose two lights come on in random order with the restriction that the left light comes on 75% of the time and the right light comes on 25% of the time. The task of the subject is to guess, after seeing a warning signal, which light is coming on next. Since the lights come on randomly the subject is simply guessing. The interesting result of this task is that subjects learn to match their guesses with the proportion of times the left and right lights come on. That is, in this task the subjects would guess Left 75% of the time and Right 25% of the time. The interesting thing about this result is that they will be correct only about 62% of the time and since they are instructed to be correct as often as possible this is not be best strategy to employ: In this case, the best strategy would be to guess Left 100% (rather than 75%) of the time. With this strategy the subject would be correct 75% rather than 62% of the time.

The probability learning task has been described as an implicit memory task and as such performance would be expected to be uncorrelated with intelligence. But

surprising correlations between performance and intelligence have been found in other areas. (For example, while inspection time and intelligence are correlated, Chaiken and Young (in press) have found that when discrimination between correct and incorrect is impossible, more intelligent subjects adopt a different strategy than do less intelligent subjects.) Thus the expectation in the probability learning task is that the more intelligent subjects will adopt strategies which result in more correct responses than will the less intelligent subjects. If these strategies are similar, that is, if the high-intelligence strategies are similar to each other but different from similar low-intelligence strategies, then there should be a correlation between performance on the task and intelligence. Different feedback groups are being used to encourage different strategies. If an event-matching strategy is adopted, for example, then one group, working for points, will get less than 0 points (i.e. they will get a negative number of points). Work or this experiment started in October and approximately 300 subjects will be run with our computers presenting the event matching task.

Forgetting in the elderly. A third study which we are planning to conduct using the AFOSR computers is an attempt to give an answer to the question "Why do the elderly forget?" One reason may be due to the accumulation, over the years, of an enormous amount of proactive interference. Alternatively, forgetting may be attributable to a general reduction of a person's mental and physical abilities with aging. It may be a combination of these factors. Or it may be due to something else entirely.

Studies of priming allow memory to be studied (apparently) without the proactive effects of prior learning. In the priming studies we have done under the AFOSR grant, pairs of words (e.g. moist-damp or eager-unshut) are presented and the task of the subject is to indicate if they are similar in meaning. If Yes, they press one key on the computer and if No they press another. The response measure is the reaction time of the choice response. A comparison of reaction times between the first and later presentations of the same pair would provide a measure of memory (and forgetting). Forgetting curves can be developed for specific individuals by looking at the savings in reaction times which occur with the repetition of the pairs.

Thus this method of studying memory may allow a differentiation between the elderly with real problems, i.e. they may suffer from Alzheimer's disease, or they may simply be like most of the rest of us--a little forgetful. Unfortunately, for the elderly the implications for being a little forgetful are quite different from people who are younger. As one ages, ever greater importance is placed on

memory and what is considered a simple nuisance at age 20 is viewed as a problem at age 70. Thus our study of priming effects and memory--essentially the same as we ran under the AFOSR grant--may allow us to develop a sort of diagnostic tool which will enable us to differentiate between the elderly with severe problems as compared to the elderly who forget as the rest of us do.

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